

INTEGRATED CIRCUIT CAPACITORS
HAVING DOPED HSG ELECTRODES

Cross-Reference to Related Application

This application is a divisional of U.S. Application Serial No. 09/735,244,
filed December 12, 2000, ^{PT 6,624,069} which is a continuation of U.S. Application Serial No.
09/036,356, filed March 6, 1998, now U.S. Patent No. 6,218,260, the disclosures of
5 which are hereby incorporated herein by reference.

Field of the Invention

The present invention relates to methods of forming integrated circuits and
circuits formed thereby, and more particularly to methods of forming integrated
10 circuit capacitors and capacitors formed thereby.

Background of the Invention

The demand for higher capacity semiconductor memory devices has resulted
in improved techniques to form memory devices and structures therein at higher
15 levels of integration. However, because higher levels of integration typically require
memory devices having smaller unit cell size, the area occupied by a cell capacitor in
a memory device, such as a DRAM device, may have to be reduced significantly. As
will be understood by those skilled in the art, this reduction in cell capacitor area can
degrade memory cell performance at low voltages and adversely impact soft-error rate
20 (SER) caused by α -particle radiation.

Conventional methods of increasing cell capacitor area include forming cell
capacitor electrodes (e.g., storage electrodes) with hemispherical grain (HSG) silicon
surface layers. For example, a conventional method of forming HSG silicon surface
layers on cell capacitor electrodes is disclosed in U.S. Patent No. 5,407,534 to
25 Thakur. However, while capacitors having HSG surface layers therein (hereinafter
"HSG capacitors") have manifested enhanced capacitance in high density integrated
circuits, HSG capacitors may lack stability and may incur performance degradation
over the lifetime of an integrated circuit memory device. Studies have shown that the
capacitance of a conventional HSG capacitor can vary greatly with respect to the